RESEARCH HIGHLIGHT

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High-performance Stucco for Housing

INTRODUCTION

Stucco or Portland cement plaster is widely used as an exterior cladding material in Canada. In some regions, particularly those with heavy rainfall, there have been moisture-related problems in wall systems clad with stucco.

Studies show that stucco cladding with low liquid diffusivity and higher water-vapour permeability can positively influence the overall moisture management capacity of wood-frame stucco walls. For this reason, Canada Mortgage and Housing Corporation, in cooperation with the National Research Council's Institute for Research in Construction, conducted research to improve the performance of stucco cladding by modifying existing stucco design mixes and testing new materials.

OBJECTIVES

This research investigated several high-performance stucco materials. For the study, high-performance stucco was defined as stucco that limits water entry on its exterior surface (liquid diffusivity) and, at the same time, allows water vapour (water-vapour permeability) to move through the stucco assembly and escape to the exterior.

The research considered stucco as an isolated material component of the exterior wall system—the project did not investigate system performance of the wall assembly with stucco as a cladding. The effects of imperfections, defects and anomalies typically found in exterior wall systems were beyond the scope of this investigation.

Computer-based simulation demonstrated that the combined wetting and drying potential of wood-frame stucco walls is significantly influenced by liquid diffusivity and the water-vapour permeability of the stucco material.

Liquid diffusivity defines the rate of movement of water within a material, induced by a water concentration gradient. A material that allows liquid-water diffusion through its boundary surface would change its weight with time when it is brought in contact with liquid water. For this study, the water-absorption coefficient was taken as a measurement of liquid diffusivity or rate of movement of water within a material (in accordance with the ISO Standard ISO 15148:2002).

Water-vapour permeability is the rate of water-vapour transmission per unit area per unit of vapour-pressure differential under specified test conditions.

RESEARCH

There were two phases to the experimental work. Phase I established the basic moisture-transport properties, water-vapour permeabilities and water-absorption coefficients of four stucco materials currently used in Canada (the base-case stuccos), including one mix based on the requirements of the National Building Code of Canada (NBCC).

In Phase II, researchers tested four, trial high-performance stucco materials having lower water-absorption coefficients but higher water-vapour permeabilities than the base-case stucco materials tested in Phase I.

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Three stucco samples were cast for each type of stucco mix in a 380 mm by 380 mm (14.9 in. x 14.9 in.) (internal dimension) wood frame. The thickness of each stucco sample after curing was approximately 21 mm (0.8 in.) (See Figure 1.). Metal lath was placed within the scratch coat. No sheathing membrane was placed between the metal lath and the bottom plate of the wood frame. The stucco mixes were prepared in conformance with manufacturers' instructions or in conformance with the NBCC stucco mix design.

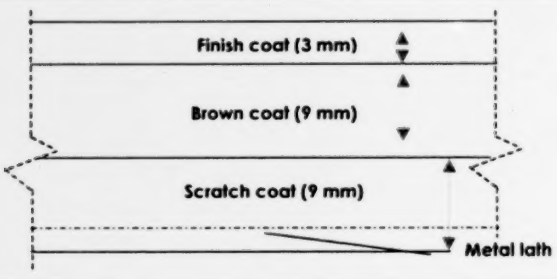

Figure 1 Typical composition of test samples

PHASE I—BASE-CASE STUCCOS

Four base-case stucco mixes were investigated:

1. N1—Commercial stucco I
2. N2—Commercial stucco II
3. N3—Commercial stucco III
4. N4—NBCC stucco

N1, N2 and N3 were representative commercial stucco mixes from different regions of Canada. N4 was a stucco mix meeting the requirements of NBCC Article 9.28.5.

PHASE II—STUCCOS MODIFIED FOR HIGH PERFORMANCE

Four different options were investigated:

1. M1—Using hydrophobic coating on exterior surface
2. M2—Using hydrophobic aggregate
3. M3—Using aggregates coated with hydrophobic chemical
4. M4—Using zinc stearate as an admixture

M1—Hydrophobic coating on exterior surface

Hydrophobic (water repelling) materials have low affinity to liquid water. Trial mix M1 was made by applying the hydrophobic chemical triethoxy-n-octylsilane directly on the exterior face of the base case stucco N4. Two coatings were applied 24 hours apart and the samples were allowed to dry for at least seven days before conducting the water-vapour permeability and water-absorption tests.

M2—Use of hydrophobic aggregate

Hydrophobic aggregates allow free, convective air movement through their pores but repel liquid water coming in contact with them. It was speculated that the presence of such aggregates in a stucco mix would reduce the water-absorption capacity of the stucco material without reducing its ability to transport air and water vapour across it.

M2 was comprised of high PH hydrophobic aggregate obtained from SilCoat Ltd. Five mix designs with different proportions of hydrophobic aggregate were tested, each cast in one coat and having a thickness of approximately 13 mm (0.5 in.).

M3—Use of aggregates coated with hydrophobic chemical

For trial mix M3, the graded, dry, natural sand (the same used for N4—NBCC stucco) was soaked in a hydrophobic liquid, octyltriethoxysilane and then dried before being incorporated into the stucco mix.

M4—Zinc Stearate as hydrophobic admixture

Zinc stearate is a zinc soap that repels water. It has already been demonstrated to decrease liquid water transport and water-vapour sorption capacity in plaster. For mix M4, zinc stearate was used as an admixture to the N4 base-case mix design.

FINDINGS

Figures 2 and 3 summarize the overall experimental results obtained from this project.

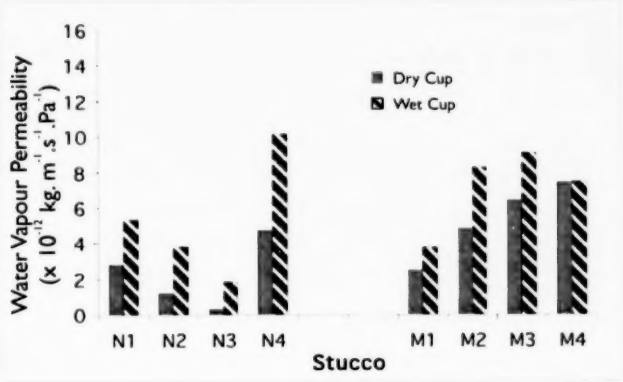

Figure 2 Water-vapour permeability of base case (N1, N2, N3, N4) and modified stucco materials (M1, M2, M3, M4)

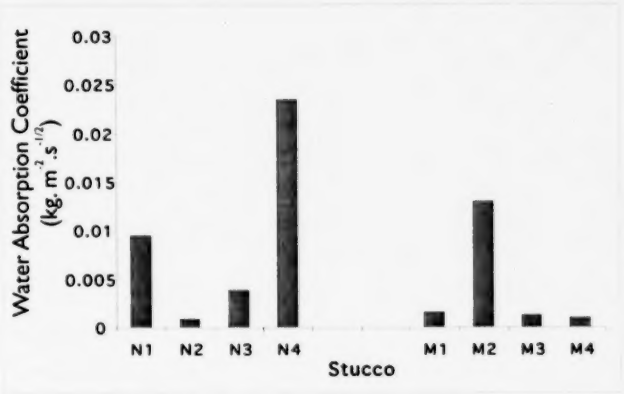

Figure 3 Water absorption cœfficient of base case (N1, N2, N3, N4) and modified stucco materials (M1, M2, M3, M4)

In assessing the results, it is important to remember that high-performance stuccos need to both:

a) limit water entry from the exterior, and

b) allow trapped moisture to escape to the exterior.

The M1 trial mix (hydrophobic coating) reduced the water absorption but also resulted in low moisture permeability. M2, the stucco mix containing the hydrophobic aggregate, had the highest water-absorption cœfficient.

M3, the trial stucco using aggregates coated with hydrophobic chemical, and M4, the mix using zinc stearate as an admixture, showed promising results. Both had relatively low water-absorption coefficients combined with high water-vapour permeability compared to the base stucco materials used in Canada.

CONCLUSIONS

This research showed it is possible, through appropriate mix design, to reduce the water-absorption coefficient of the stucco material without reducing water-vapour permeability.

The use of aggregates coated with hydrophobic chemical (trial mix M3) and the use of zinc stearate as an admixture (trial mix M4) gave promising results. They demonstrated the ability to lower liquid-water absorption capacity and have normal or higher water-vapour transmission capacity compared to stucco materials currently used in Canada.

This pilot study using small-scale specimens showed positive results. The next step in improving the performance of stucco will be testing the overall hygrothermal behaviour of the modified stucco materials on full-scale wall systems.

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Research report: *Development of High Performance Stucco for Durable Housing Construction—A Pilot Study*

Housing Research at CMHC

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